Development of Cost-Effective Low-Permeability Ceramic and Refractory Components for Aluminum Melting and Casting

Benefits

Enhancement of the pressure-holding capacity of fused silica tubes and their implementation in aluminum melting and casting can lead to

- Significant energy benefits and
- Produce results that will also enhance the performance of refractories in the aluminum, glass, and chemical industries.

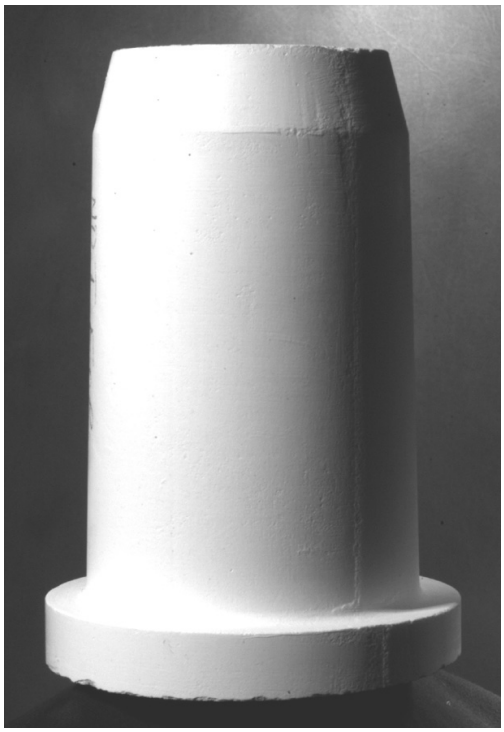
Applications

Improved ceramic and refractory components from this program will be applicable to many industries.

- **Aluminum and Metalcasting:** Melting and casting of aluminum and its alloys.
- **Chemical and Petrochemical:** Improved corrosion resistance to enhance performance of several types of chemical reactors.
- **Glass:** Potential for enabling oxy-fuel firing.

Improved ceramics and refractories will improve low-pressure aluminum metal-casting processes

The project will develop optimized ceramics and refractory components with low permeability to gases for applications involving low-pressure casting and contact with molten aluminum. The work will focus on the development of improved coatings, functionally graded materials, and monolithics that will hold gas pressure. Other requirements include enhanced combinations of properties, including resistance to thermal shock, erosion, corrosion, and wetting. When these materials are successfully deployed in aluminum smelting and casting operations, their superior performance and durability will enable end users to achieve marked improvements in uptime, defect reduction, scrap/rework costs, and overall energy savings.



Pyrotek fused-silica tube

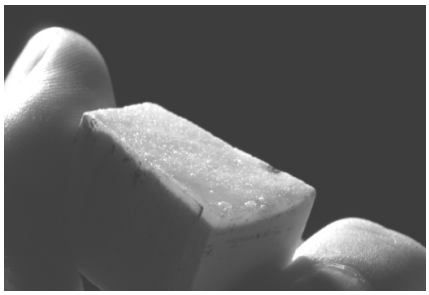
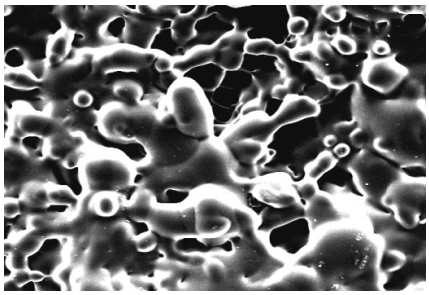


Photo of nozzle surface melted using ORNL high-intensity IR lamp



SEM photo of melted surface

Project Description

Goal: The focus of this project is to develop and validate new classes of cost-effective low-permeability ceramic and refractory components for handling molten aluminum in both smelting and casting environments. The primary goal is to develop materials and methods for sealing surface porosity in thermal-shock-resistant ceramic refractories, which will also include the evaluation of molonilthics used in the low-pressure casting of aluminum.

Issues: The major issue for this project is for the ceramic/refractory to hold gas pressure in the delivery tubes for aluminum metalcasting. The issue is related to porosity, which can be closed by either a surface modification or changes in the bulk refractory chemistry. Both approaches will be evaluated in this project.

Approach:
The approach includes
– Understanding the failure mode of refractory tubes in molten aluminum,
– Characterizing of the porosity in delivery tubes,
– Evaluating monolithic tube materials,
– Developing and optimizing the surface modification process to close the porosity, and
– Choosing a refractory powder blend that minimizes the porosity.

Potential payoff:
– More efficient melting and casting of aluminum alloys.
– Improved chemical and glass manufacturing processes.
– Reduced scrap and downtime.

Progress and Milestones

- Complete characterization of currently produced refractory aluminum delivery tubes.
- Complete studies of surface modifications using high-density infrared processing facility.
- Complete formulating bulk compositions for full densification.
- Evaluate monolithic materials.
- Complete testing of prototype components in low-pressure aluminum metalcasting production conditions.

Primary

Pyrotek, Inc.
Trenton, TN

Project Partners

Oak Ridge National Laboratory
Oak Ridge, TN

Progress Castings
Plymouth, MN

University of Missouri Rolla
Rolla, MO

For Additional Information, Please Contact

EERE Information Center
Phone: (877) 337-3463
Fax: (360) 236-2023
eereic@ee.doe.gov

Visit our home page at
http://www.eere.energy.gov/industry/

Office of Industrial Technologies
Energy Efficiency
And Renewable Energy
U.S. Department of Energy
Washington, DC 20585
http://www.oit.doe.gov

January 2002

ORNL 2002-01722/chj